November 24, 2014

**Via Electronic Mail**

Mr. Will Geiger (3HS21)
Eastern PA Remedial Branch
United States Environmental Protection Agency – Region III
1650 Arch Street
Philadelphia, Pennsylvania 19103-2029

**Re: Response to Comments on Sheet Pile Wall Repair Work Plan Metal Bank NPL Site, Philadelphia, Pennsylvania, October 2014**

Dear Mr. Geiger,

We have reviewed the United States Environmental Protection Agency (USEPA) November 3, 2014, comments to the October 2014 Sheet Pile Repair Work Plan for the Metal Bank Cottman Avenue Superfund Site (the "work plan"). This letter represents our response to these comments. We have made several changes to the work plan based on the USEPA comments. An updated version of the work plan will be transmitted to you for review under separate cover.

This letter follows the organization of USEPA's comment letter, which identified four issues, numbered sequentially from 1 to 4. Our responses to each of USEPA's comments are provided below, with an indication of which changes, if any, were made to update the work plan:

***Comment 1:*** *The plan essentially identifies a single repair option and does not address the root cause of the damage / failure. An evaluation of the root cause(s), and the subsequent repair proposal, should be included in the work plan. The evaluation should specifically address the placement of the deadmen in structural fill, including fill placed behind the wall at the time of its installation.*

**Response**: Although ENVIRON and RAC considered other repair options as part of the original analysis of the sheet pile wall, we agree with the commenter that we failed to present these other repair options in the work plan. We have revised the work plan to include the principal alternative option considered during the analysis of this structure (see Section 3.2 of the updated work plan). Regarding the root cause analysis, we refer the commenter to section 2.2 of the work plan, which states that the design of the sheet pile wall did not account for the additional stress at low tide, and is as a result, under-designed. Further, the geotechnical analysis performed by RAC indicated a global stability issue or potential global failure. Global failure is caused by a failure of the soil below the sheet pile wall and structural fill surrounding the deadmen, and, as such, the evaluation did consider the deadmen and structural fill, though it was not explicitly stated in the work plan.

***Comment 2:*** *The proposed berm is permanent fill that requires mitigation under the Clean Water Act. Alternative repair options must be considered as part of the mitigation analyses. Any work plan or repair proposal must include a mitigation plan.*

20 Custom House Street
Boston, MA 02110

**environcorp.com**

**Response**: This comment is a compound comment consisting of several separate statements. The first and third statements in this comment note that the proposed riprap buttress will require mitigation and a mitigation plan. Based in part on the fact that this proposed repair will create less of an impact than the original remedy, and since the original remedy at the site did not require a mitigation plan, the proposed repair also does not require mitigation. As a point of reference, the marine mattress placement and the nearshore sediment removal affected areas of approximately 1.2 and 1.0 acres, respectively, whereas the proposed riprap buttress is expected to impact less than 0.5 acres.

In a second statement, the commenter states that alternative repair options must be considered. As described in our response to Comment 1, we have added an alternative repair option to the updated work plan (section 3.2). The alternative option is the “upland option”, which consists of repairing the cracked waler and installing an additional row of deadmen, offset from the original deadmen and located at a deeper soil depth and at a greater distance from the sheet pile wall. The new row of deadmen would be secured to an additional waler with tie rods, similar to the original deadmen installation. Significant excavation would be required under this approach. With the upland repair option, greater than 1 acre of the soil cover would have to be removed and replaced. In addition, the surface vegetation in the disturbed areas would have to be restored, which would take greater than 3 years to re-establish.

Though we have included a description of this alternate approach in the updated work plan, we will not be recommending this alternative approach be implemented at the site for the reasons described below. Compared to the originally proposed repair option described in the work plan, the alternative option:

- Does not minimize disturbance of previously constructed remedy components, such as the upland soil cap, the underlying polychlorinated biphenyl (PCB) contaminated soils, or the nearshore backfill area;
- Will result in some site soils migrating into the river environment during remedy implementation, despite implementation of best erosion control practices;
- Does not represent a practical approach that can be constructed in the near term; and,
- Does not minimize the disturbance of the restored upland and intertidal habitat adjacent to the sheet pile wall.

We have included a description of these additional considerations in Table 2 of the updated work plan.

***<u>Comment 3:</u>*** *The extensive use of riprap will obscure direct inspection of the wall below elevation 0. This will eliminate the ability to observe any seepage / sheen potentially associated with the failure of other components of the remedy.*

**Response:** We agree that it is necessary to evaluate whether PCB oils are migrating off-site. However, we do not share the commenter’s concern that the placement of riprap limits our ability to do so. As part of the final remedy, a light nonaqueous-phase liquid (LNAPL) interceptor trench was installed near the sheet pile wall to determine if PCB oils were at risk of migrating off-site. The proposed placement of the riprap will not affect the LNAPL trench or its ability to evaluate the presence of PCB oils. In addition, it warrants stating here that no oil sheens have been observed in the LNAPL trench since its construction in 2009 and PCB concentration in groundwater at the Site are consistently below drinking water standards (even though these standards do not apply to this site).

***Comment 4:*** *It should also be noted that proposed berm will eliminate habitat for aquatic biota. As such, it constitutes natural resource damage in perpetuity that was not included in the remedy evaluation. Because of this and the previously noted 404 considerations, the BTAG strongly recommends that alternative repair approaches with minimal or temporary effects to the river habitat be considered and presented for consideration.*

**Response:** In response to this comment, we have presented an alternative repair approach in the update work plan (section 3.2). As mentioned previously, the alternative approach is an option we refer to as the "upland option," which minimizes effects to the river habitat. However, as discussed in our response to Comment 2 and section 3.2 of the updated work plan, we do not propose the upland option be implemented at the site. Table 2 in the updated work plan provides a side-by-side analysis of the upland and the riverside repair options. The riverside option outperforms the upland option in almost all areas. With respect to the commenter's concerns regarding the loss of aquatic habitat quality under the riverside option, we do not believe this to be significant for the following reasons:

1. As documented in the Long Term Monitoring Annual Reports, the mudflat represents a low quality habitat with low abundance and diversity. This is likely due to the physical nature of the habitat and the low abundance and diversity observed in similar oligohaline - limnetic intertidal mudflat habitats such as the reference areas. The proposed repair will only impact a small area of the current mudflat (<0.5 acres).
2. The riprap will be confined to the dredge area. Dredge fill was composed of R-3 stone with a nominal size of 3–6 inches. The placement of additional riprap with a similar or larger stone size does not represent a dramatic alteration of the characteristics of the substrate. R-3 stone is unsuitable for many infaunal organisms, and therefore the placement of a riprap berm does not represent a loss of habitat.
3. As documented in numerous references (Friesen 2005; Davis et al. 2006; and White et al. 2009) the current sheet pile retaining wall represents a very low quality habitat. Currently the retaining wall provides limited cover for fish and only an exposed vertical wall for the settlement of epifauna. By buttressing the retaining wall with large stone, complex habitat will be created (Quigly and Harper 2004). This habitat will provide cover for fish and invertebrates, crevasses and sediment pockets that will protect organisms from desiccation during low tide, and a reef like habitat during high tide (Friesen 2005). Davis et al. (2006) and White et al. (2009) reported greater abundance and diversity in riprap as compared to bare sediment. As documented in the papers included in Friesen (2005) for the Lower Willamette River, a freshwater intertidal habitat that is similar to the Delaware River, stone riprap represents a shoreline stabilization technique that provides complex habitat that is superior to a simple retaining walls and does not reduce species abundance and diversity when compared to bare sediment.

Should you have any comments or questions related to our responses, don't hesitate to contact me.

Sincerely,

Joseph P. Vitale

Joseph Vitale, PE, LSP
Principal Consultant

Cc: Cottman Avenue PRP Group

## References

Davis JLD, RL Takacs, and R Schnabel. 2006. Evaluating Ecological Impacts of Living Shorelines and Shoreline Habitat Elements: An Example from the Upper Western Chesapeake Bay. In: Management, Policy, Science, and Engineering of Nonstructural Erosion Control in the Chesapeake Bay Proceedings of the 2006 Living Shoreline Summit. http://www.vims.edu/cbnerr/_docs/ctp_docs/ls_docs/06_LS_Full_Proceed.pdf.

Friesen TA. 2005. Biology, Behavior, and Resources of Resident and Anadromous Fish in the Lower Willamette River Final Report of Research, 2000–2004. Edited by Thomas A. Friesen Oregon Department of Fish and Wildlife 17330 Southeast Evelyn Street Clackamas, Oregon 97015 March 2005 Contracted by City of Portland. http://www.portlandoregon.gov/bes/article/79249.

Quigley JT and DJ Harper. 2004. Streambank protection with rip-rap: an evaluation of the effects on fish and fish habitat. Can. Manuscr. Rep. Fish. Aquat. Sci. 2701: xiv + 76 p. http://www.dfo-mpo.gc.ca/Library/285541.pdf.

Seitz RD, and AS Lawless. 2006. Landscape-Level Impacts of Shoreline Development on Chesapeake Bay Benthos and Their Predators. In: Management, Policy, Science, and Engineering of Nonstructural Erosion Control in the Chesapeake Bay Proceedings of the 2006 Living Shoreline Summit. http://www.vims.edu/cbnerr/_docs/ctp_docs/ls_docs/06_LS_Full_Proceed.pdf.

White K., J Gerken, C Paukert, and A Makinster. 2009. Fish community structure in natural and engineered habitats in the Kansas River. River Research and Applications, 26(7):797–805. http://web.missouri.edu/~paukertc/reprints/KSR%20rip%20rap%20White.pdf.

# Sheet Pile Wall Repair Work Plan

Metal Bank Cottman Avenue Superfund Site

Prepared for:
**USEPA Region III**
**Philadelphia, PA**

On behalf of:
**Cottman Avenue PRP Group**

Prepared by:
**ENVIRON International Corporation**
**Boston, Massachusetts**

Date:
**November 2014**
**(Revision #1)**

Project Number:
**33-34792G**

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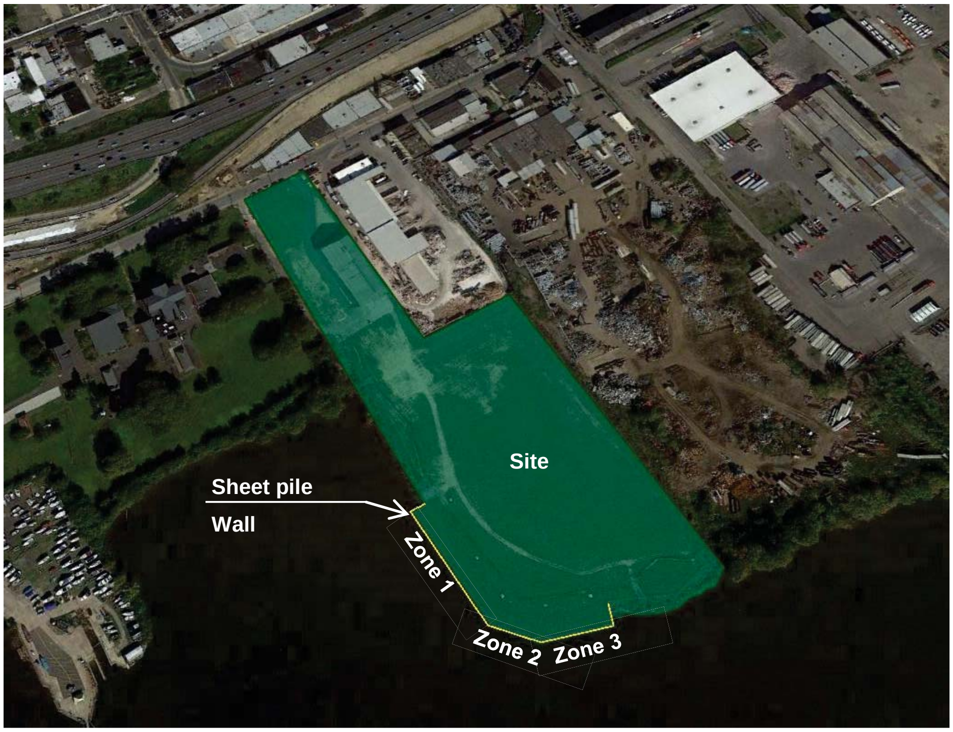
# Acronyms and Abbreviations

| | |
|---|---|
| USEPA: | United States Environmental Protection Agency |
| RAC: | RA Consultants, LLC |
| PRP: | Potentially Responsible Party |
| Kips: | Unit of Force Equaling 1000 Pounds-force |
| LSP: | Licensed Site Professional |
| PE: | Professional Engineer |

# 1 Background

Installation of the sheet pile wall at the Metal Bank Cottman Avenue Superfund Site ("the Site") was completed in 2010, as a component of the final remedy selected for the Site. The primary purpose of the sheet pile wall is to prevent the erosion and potential migration of upland soils into the Delaware River and surrounding mudflats. A site plan showing the location of the sheet pile in relation to the Site is provided below.




Following the installation of the sheet pile, routine monitoring has been performed to evaluate the physical and structural integrity of the sheet pile. Signs of movement in the sheet pile were first observed during a site inspection in 2012. Subsequent inspections and evaluations have determined that certain components of the sheet pile are damaged and that repairs appear to be warranted. This work plan describes the results of the structural sheet pile evaluations and provides recommendations for repairs. This document is being presented for review by USEPA as an initial deliverable to address the identified issues. More detailed plans and specifications will be prepared and provided to USEPA once the scope of work presented in this document has been accepted in concept. The flaws identified by our analysis have, to date, not compromised the sheet pile's ability to prevent offsite soil migration.

# 2 Current Sheet Pile Condition

## 2.1 Sheet Pile Inspections

Sheet pile inspections were performed in November 2012 and April 2014 by RA Consultants (RAC), an independent geotechnical engineer retained by the Cottman Avenue PRP Group (the Group). RAC made the following observations of current sheet pile conditions:

- The north side of Zone 1 shows movement of the sheet pile wall system. The epoxy coating on the face of the wale has been scraped and removed providing evidence that the tieback plates have moved relative to the wale.

In addition, the wale and sheet pile wall appear to be bowing with the apex of the bow at the bolted connection and there appears to be additional movement of the tieback plates relative to the wale.

- Cracks and separation of the wale were observed where the sheet pile wall changes direction (turns east) in Zone 2. The miter cut and joint where the wales meet at the corner was cracked. The cracks appear to be stress (tension) cracks. The wale cracked (failed) at this location due to movement of the wall toward the river.

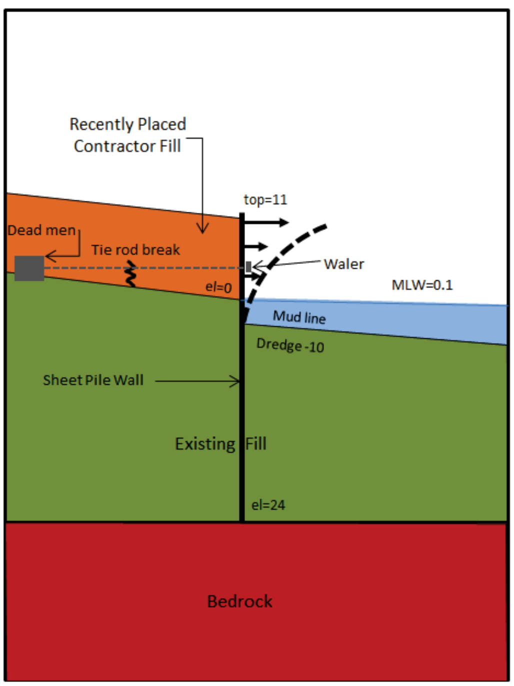
- The west side of Zone 3 shows signs of movement of the sheet pile wall system. The epoxy coating on the face of the wale has been scraped and removed providing evidence that the tieback plates have moved relative to the wale. No landside access to this area. No significant signs of movement observed from the watercraft.

## 2.2 Geotechnical Modeling and Analysis

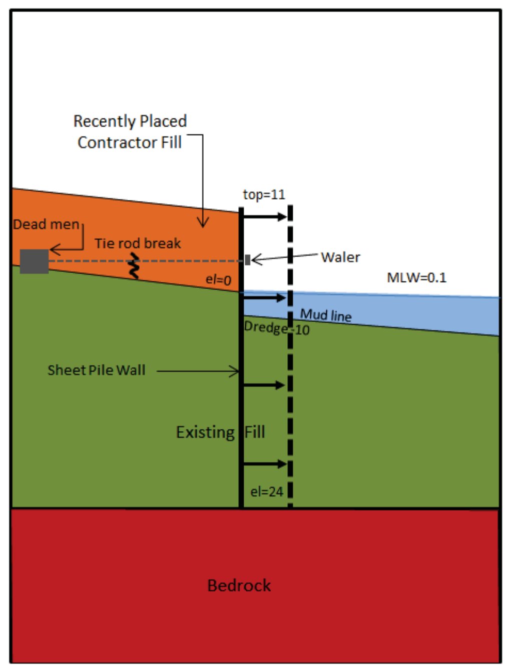
RAC performed geotechnical modeling and analysis to evaluate the cause of the observed sheet pile movement. Refer to Appendix 1 for RAC's detailed geotechnical modeling and analysis of the sheet pile wall. Specifically, RAC sought to gain a better understanding of why the Zone 2 wale failed and why the sheet pile wall moved at the Zone 1 return section. Using state-of-art geotechnical software, RAC simulated the loads on the tie-rods and the lateral loads on the sheet pile wall under high and low tide conditions for all three zones. These simulations allowed RAC to assess the likelihood of imminent structural and/or global stability failure occurring in the various zones of the sheet pile wall.

Structural failure describes the movement of the sheet pile wall above the mud line in the direction of the river. Global stability failure describes the overall movement of the sheet pile over the entire length of the wall above and below the mud line in the direction of the river. The two types of failure are represented schematically below.

**Structural Failure**




**Global Failure**




RAC's review indicated that previous geotechnical analyses of as-built conditions were performed for high water conditions only. RAC analyzed both the high water and low water conditions, and obtained the following modeled results:

- <u>High water conditions:</u> The simulated tie-rod loading (114.84 Kips) slightly exceeded the allowable tie-rod loading (108 Kips). The global stability failure envelope extends 38 feet laterally, just 2 feet short of the distance to the dead men (40 feet), providing minimal protection against sliding failure. The sheet pile wall is not materially overstressed and insignificant movement of the wall is anticipated.

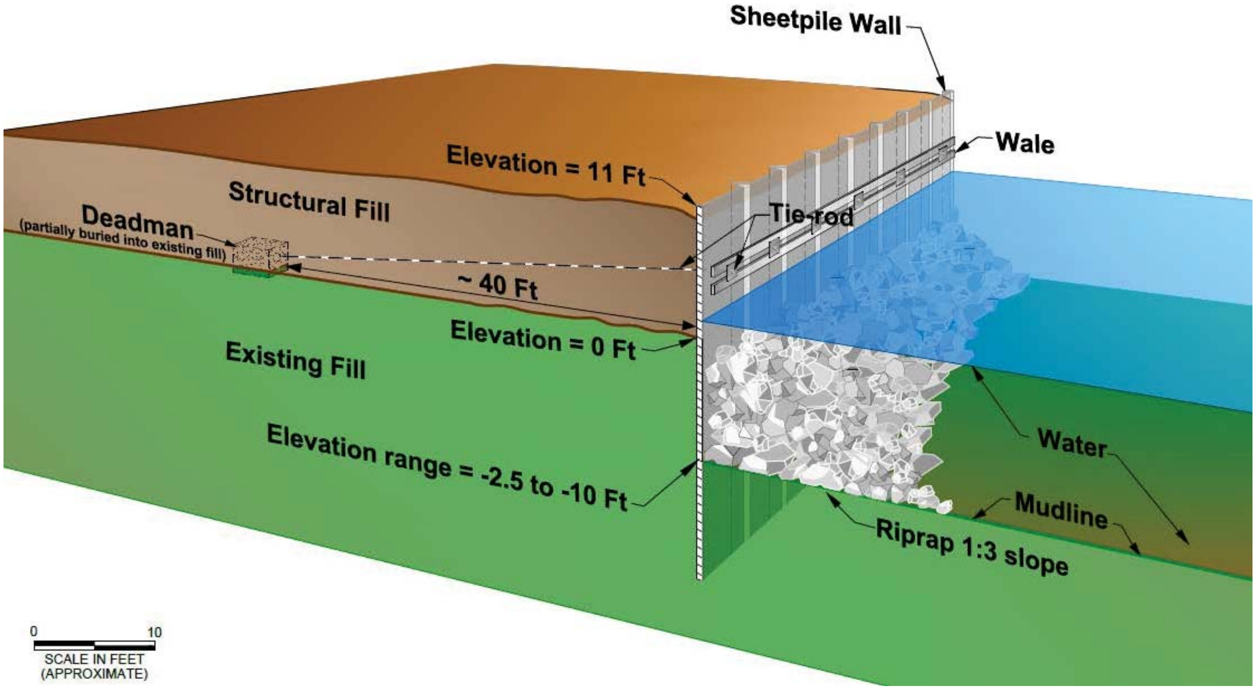
- Low water conditions: The simulated tie-rod loading (206.52 Kips) significantly exceeded the allowable tie-rod loading (108 Kips). The global stability failure envelope extends 41 feet laterally, which is beyond the position of the dead men, providing no protection against sliding failure. The sheet pile wall is locally overstressed at the tie-rods and significant movement of the wall is anticipated. The additional stresses under low water conditions are likely a major contributor to the wale failure and movement of Zone 1 return wall observed in the field.

Based on RAC's analysis there is insufficient safety built into the sheet pile design in its current condition.

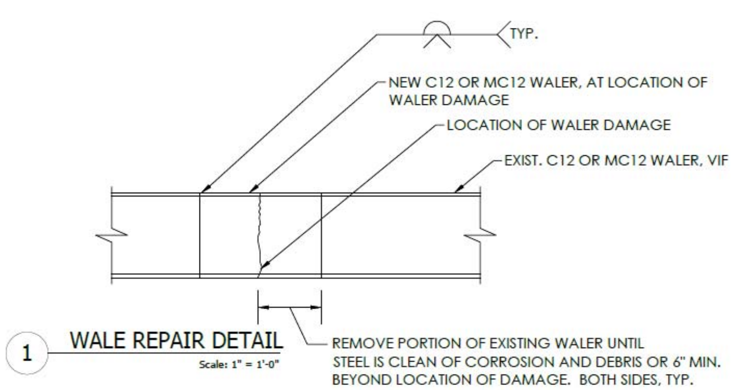
# 3 Recommendations

## 3.1 Option 1 – River-side Repairs

A first option to address the issues identified during the geotechnical analysis is to repair the cracked waler and place rip rap on the river side of the sheet pile wall up to elevation 0 (Option 1). These repairs address both the structural and global stability of the sheet pile wall under low water conditions. A schematic of the proposed Option 1 is shown below.




RAC recommends performing the waler repairs after the rip rap has been placed. A schematic of the proposed waler repairs in areas of visible cracks or separation is shown below.

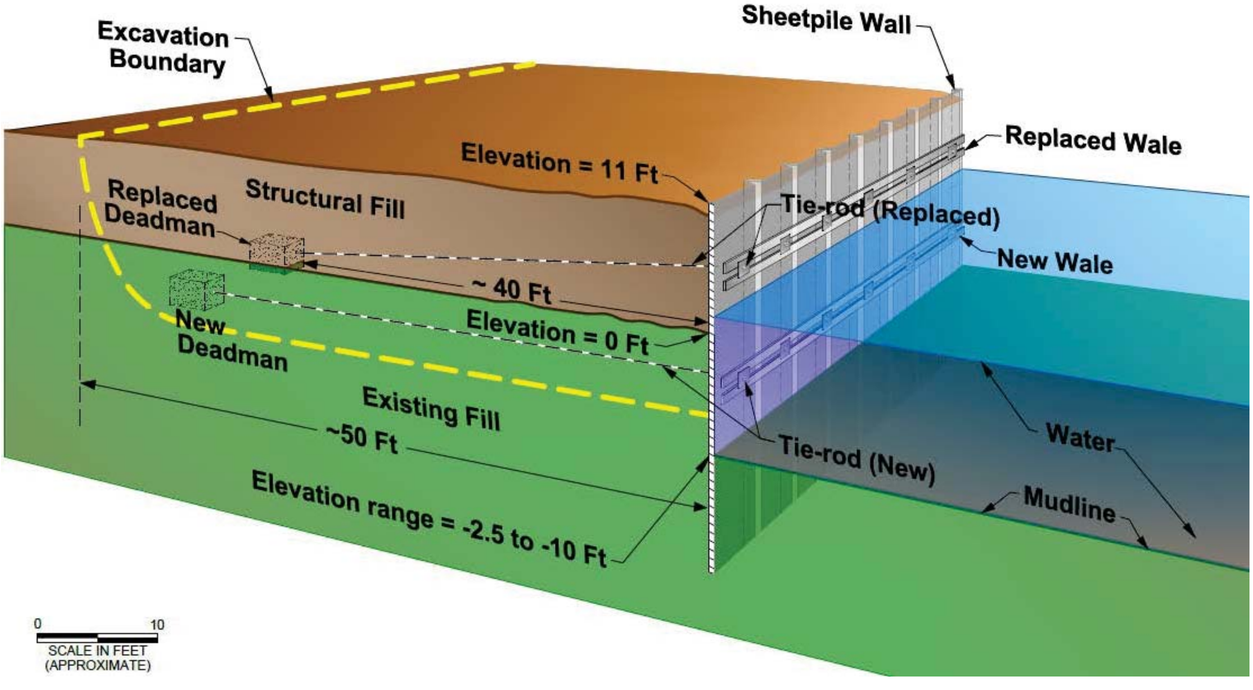


At the direction of ENVIRON, Aqua Survey, Inc. (Aqua Survey) conducted a near-shore bathymetric survey to provide the information necessary to estimate the quantities of rip rap needed to raise the mud line to elevation 0. The details of this bathymetric survey are presented in Appendix 2.

In addition to the repairs proposed above, RAC previously recommended a detailed topside survey program to measure the movement of the wall in the x, y, and z directions, and evaluate the immediacy of the proposed repairs. The survey program was implemented in September and October 2014, and is scheduled to continue every month until the end of the calendar year.

### 3.2 Option 2 – Upland-side Repairs

A second option to address the issues identified during the geotechnical analysis is to repair the cracked waler and install an additional row of deadmen, offset from the original deadmen and located at a deeper depth and at a greater distance from the sheet pile. The new row of deadmen would be secured to an additional waler with tie-rods, similar to the original deadmen installation (Option 2). These repairs address both the structural and global stability of the sheet pile wall under low water conditions. A schematic of the proposed Option 2 is shown below. As shown in the plan view image, Option 2 would require the excavation of soil cap and underlying contaminated soils from the sheet pile to the new line of deadmen, approximately 50 feet inland.




### 3.3 Option Analysis

In order to evaluate the two proposed options, we considered a set of decision criteria, shown in Table 1, on the following page. These criteria were based on how the repair options are expected to affect existing remedial components, habitats, and erosion potential, and how practical and implementable each option is expected to be.

**Table 1: Additional Analysis of Proposed Repair Options 1 and 2**

| Decision Criteria | Option 1<br>(River-side Repair) | Option 2<br>(Upland-side Repair) |
|---|---|---|
| Disturbance of upland soil cap | **Minimal**. Minor surface disturbance possible from heavy equipment traffic during rip-rap placement. | **Severe**. Entire soil cap will be excavated between the sheet pile and proposed deadmen 50 feet inland. |
| Disturbance of PCB contaminated soils | **None**. | **Severe**. PCB contaminated soils will require handling and excavation to install new proposed deadmen. |
| Disturbance of near-shore backfill area | **Minimal**. Minor disturbance may occur during placement of rip-rap. | **None**. |
| Effect on erosion potential | **Minimal**. Surface traffic during rip-rap placement may cause temporary and minor surface erosion. | **Severe**. Heavy soil disturbance expected from excavation activities. Excavated portion of the site will be devegetated. |
| Practicality | **High**. Relatively straightforward land-side placement of inert material on river-side of sheet pile. | **Low**. Removal of previously implemented remedy components and handling of PCB-contaminated soils not considered highly practical. |
| Implementation Timeframe | **Short term**. Implementable within 6 months. | **Medium term**. Implementable within 1 year. |
| Effect on restored upland habitat | **Minimal**. Minor disturbance may occur during placement of rip-rap. | **Severe**. Upland habitat will be removed during excavation. |
| Effect on restored intertidal habitat adjacent to sheet pile | **Moderate-Slight Enhancement**. Intertidal area is a low-quality habitat that does not support a large number of species. Rip-rap placement will bury a small amount of mudflat habitat. The current sheet-pile wall is very low quality habitat. The addition of a riprap buttress is expected to result in a net enhancement of habitat adjacent to the wall. | **None**. |

Based on the above, we recommend Option 1 (River-side Repair) for implementation at the Site.

To confirm that the proposed option provides the structural and global stability needed, RAC re-ran the geotechnical model under low water conditions for the river-side repair option. Table 2, below, summarizes the results of RACs analysis:

**Table 2: RAC Geotechnical Analysis of Proposed Repairs for River-side Repair Option**

| Sheet pile Wall Zone | Structural Stability | | Global Stability | |
|---|---|---|---|---|
| | **Predicted Stress (Kips)** | **Allowed Stress (Kips)** | **Predicted Safety Factor** | **Required Safety Factor** |
| Zone 1 (Tidal Mudflat Side) | 75 | <108 | 1.96 | >1.5 |
| Zone 2 (Confluence of River and Mudflat Side) | 81 | <108 | 2.135 | >1.5 |
| Zone 3 (River Side) | 41 | <108 | 1.81 | >1.5 |

The results of the model show that the proposed repair option is an effective solution, and increases both the structural and global stability to acceptable levels.

### 3.4 Next Steps

In addition to continuing the monthly sheet pile wall surveys through the end of the year, we propose to develop design drawings and technical specifications to support the Group's efforts to retain a contractor to execute the proposed repair.

# 4 Closing

This document provides the proposed conceptual approach to repair the sheet pile wall at the Site. More detailed design drawings and specifications will be prepared following your approval of the approach and the completion of additional survey work. Should you have any questions or comments regarding the contents of this document, don't hesitate to contact me.

Joseph P. Vitale

Joseph Vitale, LSP, PE

# Appendix 1

**RA Consultants LLC**
**Sheet Pile Wall Analysis**
**October 14, 2014**

RA Consultants LLC

Geotechnical Engineering

Walter J. Papp, Jr., Ph.D, P.E.
Senior Partner

Nidal M. AbiSaab, P.E.
Partner

Robert Alperstein, P.E.
Consultant

October 14, 2014

12C1135

Mr. Joseph Vitale, PE, LSP
ENVIRON International
20 Custom House Street
Boston, MA 02110

Re: Sheet Pile Wall Analysis
Metal Bank NPL Site
7301 Milnor Street
Philadelphia, PA 19136

Dear Mr. Vitale,

This letter is provided in accordance with our proposal dated June 23, 2014. It covers review and analysis of existing data and recommendations for temporary repair of the Metal Bank sheet pile wall.

**EXECUTIVE SUMMARY**

In order to provide repair recommendations for the sheet pile wall located at the Metal Bank NPL Site, we first analyzed the as built construction of the sheet pile wall to determine the wall and tie rod loading and potential failure mode.

We reviewed design and construction documents dating at or before the time of construction. Of primary interest was the design analysis provided by AMEC Earth & Environmental, Inc. AMEC performed an as-built analysis of the sheet-pile wall, which accounted for installed sheet-pile embedment depths that were shorter than required on design drawings.

While the AMEC analysis found the sheet pile wall to be sufficient for as-built conditions, we noted that AMEC only checked the design at mean high water conditions both in front and behind the wall. We performed an analysis of the sheet pile wall for mean low water conditions and found several modes of failure for the sheet-pile wall including, overstressed tie-backs, overstressed sheet piles, and global stability failure including the dead-man tie rod anchoring system.

## ANALYSIS

### *AMEC Analysis*

Below is a summary of the model analyzed with Slope/W software as described in the "Design Memorandum" by AMEC Earth & Environmental, Inc. (Appendix A)

AMEC Design Assumptions:
- Hart-Crowser Zone 3
- Dredge Depth at 10'
- Mean High Water Level at 6.4'
- Mean Low Water Level at 0.1'
- Arbed AZ26 Sheet Pile
- Max Sheet Pile depth at -24'
- Soil Loads calculated by software based on
- Surcharge Load from 150 psf to 300 psf

CASE 1 Results: Mean High Water
Mean High Water = 6.4'
AMEC Design Results at Mean High Water:
Waler Load = 6.33 Kips/ft
Tie-rod Load = 76 Kips assuming 12'-0" spacing

According to AMEC, maximum allowed load at tie-rod was 108 Kips, therefore the revised design based on shorter installed sheet-pile lengths was acceptable.

CASE 2: Mean Low Water
According to the documents provided to us, AMEC did not provide a design check for mean low water.

### *RA Consultants Analysis Based on Parameters Used By AMEC*

Below is a summary of a model analyzed using commercial software DeepEx 2014 in order to check the above model provided by AMEC. All design assumptions were based on the model provided by AMEC in the "Design Memorandum" with exception of the surcharge load. (Appendix B)

RA Consultant LLC Design Assumptions (replica of AMEC):
- Hart-Crowser Zone 3
- Dredge Depth at 10'
- Mean High Water Level at 6.4'
- Mean Low Water Level at 0.1'
- Arbed AZ26 Sheet Pile

- Max Sheet Pile depth at -24’
- Soil Loads calculated by software based on Borings RG-6 and RG-7
- Surcharge Load set to 0 psf
- Design at Mean High Water = 6.4’
- Design at Mean Low Water = 0.1’

<u>CASE 1 Results: Mean High Water</u>
RA Consultants LLC Design Results at Mean High Water:
9.57 Kips/ft lateral load on the sheet-pile wall
114.84 Kips at Tie-rods assuming 12’-0” spacing

At 114.84 Kips, the allowable tie rod load of 108 Kips is exceeded within a 5% range.

The failure envelope for global stability failure extends 38’ laterally, almost to the 40’ location of the dead men, providing minimal protection against sliding failure.

The sheet pile wall is not overstressed and insignificant movement was calculated.

<u>CASE 2: Mean Low Water</u>
RA Consultants LLC Design Results at Mean Low Water:
17.21 Kips/ft lateral load on the sheet-pile wall
206.52 Kips at Tie-rod assuming 12’-0” spacing

At 206.52 Kips, the allowable tie rod load of 108 Kips is exceeded by 90%.

The failure envelope for global stability extends 41’ laterally behind the sheet pile thereby extending beyond the location of the dead men, providing no protection against sliding failure.

The sheet pile wall is locally overstressed at the tie rods and shows movement at the toe of 8”.

## RESULTS

According to our review, the study that AMEC provided of the sheet pile wall embedded 24’ to rock is slightly overstressed, which should not result in the movements observed in the field. The study by AMEC, however, only accounted for high-tide conditions. Our analysis for low-tide conditions found that the sheet pile wall and tie-rod were overstressed; the sheet-pile excessively deflected at the toe, and a global stability failure was encountered beyond the dead-man location.

Although movement of the sheet-pile wall has been observed on site, the 8” predicted by analytical models was not observed. This may be due to the fact that the river was not dredged to a 10’ depth or that rip-rap was placed at the location of the dredging providing a berm against the sheet-pile wall.

Repairs should be based on accurate field conditions, in lieu of the design assumptions provided by AMEC.

## REPAIR ANALYSIS

We generated independent design sections using borings provided by Ogden Environmental and Energy Services in the "Pre-Design Investigation Report", dated January 19, 2000. Data from the nearest borings, labeled RG-6 and RG-7 was obtained and interpolated in order to give an estimate of required repairs. Design sections were built for Zones 1, 2, and 3. Refer to Appendix C for model results.

Zone 1

RA Consultants LLC Design Assumptions:

- Hart-Crowser Zone 1
- Dredge Depth at 5'
- Mean High Water Level at 6.4'
- Mean Low Water Level at 0.1'
- Arbed AZ18 Sheet Pile
- Max Sheet Pile depth at -24'
- Soil Loads calculated by software based on Borings RG-6
- Surcharge Load set to 0 psf
- Design at Mean Low Water = 0.1'

CASE 1: Mean Low Water – AS BUILT

RA Consultants LLC Design Results at Mean Low Water:
6.08 Kips/ft lateral load on the sheet-pile wall
75 Kips at Tie-rod assuming 12'-4" spacing

At 75 Kips, the allowable tie-rod load of 108 Kips is adequate

The factor of safety is 1.96, greater than the industry standard required 1.5, meaning that the failure envelope for global stability protects against sliding. Observed movement at the corners in Zone 1 are likely due to overstressing of the tie-rods.

Zone 2

RA Consultants LLC Design Assumptions:

- Hart-Crowser Zone 2
- Dredge Depth at -9.5'
- Berm Depth at -5'
- Mean High Water Level at 6.4'
- Mean Low Water Level at 0.1'
- Arbed AZ18 Sheet Pile
- Max Sheet Pile depth at -25.5'
- Soil Loads calculated by software based on Borings RG-6
- Surcharge Load set to 0 psf
- Design at Mean Low Water = 0.1'

<u>CASE 1: Mean Low Water – AS BUILT  - Dredged</u>
RA Consultants LLC Design Results at Mean Low Water:
10.4 Kips/ft lateral load on the sheet-pile wall
125 Kips at Tie-rod assuming 12'-4" spacing

At 125 Kips, the allowable tie-rod capacity of 108 Kips is exceeded.

The factor of safety is 1.8, greater than the industry standard required 1.5, meaning that the failure envelope for global stability protects against sliding.

<u>CASE 2: Mean Low Water – AS BUILT  - Proposed Berm</u>
RA Consultant Design Results at Mean Low Water:
6.54 Kips/ft lateral load on the sheet-pile wall
81 Kips at Tie-rod assuming 12'-4" spacing

At 81 Kips, the allowable tie-rod capacity of 108 Kips is adequate

The factor of safety is 2.135, greater than the industry standard required 1.5, meaning that the failure envelope for global stability protects against sliding.

<u>Zone 3</u>
RA Consultants LLC Design Assumptions:
- Hart-Crowser Zone 3
- Dredge Depth at -10'
- Berm Depth at 0'
- Mean High Water Level at 6.4'
- Mean Low Water Level at 0.1'
- Arbed AZ26 Sheet Pile
- Max Sheet Pile depth at -24.5'
- Soil Loads calculated by software based on Borings RG-7
- Surcharge Load set to 0 psf
- Design at Mean Low Water = 0.1'

<u>CASE 1: Mean Low Water – AS BUILT  - Dredged</u>
RA Consultants LLC Design Results at Mean Low Water:
19.21 Kips/ft lateral load on the sheet-pile wall
231 Kips at Tie-rod assuming 12'-4" spacing

At 231 Kips, the allowable tie-rod capacity of 108 Kips is exceeded.

The factor of safety is 0.9 less than the industry standard required 1.5, meaning that the failure envelope for global stability does not protect against sliding.

CASE 2: Mean Low Water – AS BUILT - Proposed Berm
RA Consultants LLC Design Results at Mean Low Water:
3.34 Kips/ft lateral load on the sheet-pile wall
41 Kips at Tie-rod assuming 12'-4" spacing

At 41 Kips, the allowable tie-rod capacity of 108 Kips is adequate

The factor of safety is 1.81, greater than the industry standard required 1.5, meaning that the failure envelope for global stability protects against sliding

## REPAIR RECOMMENDATIONS

Phase 1 (immediate temporary repair)

Install rip-rap to berm waterside of the sheet pile wall to elevation 0. The berm should be sloped down and away from the sheet pile wall at 1V:3H. This will be confirmed after the bathymetric survey.

Temporarily berm the area waterside of the failed wale section to 2-ft depth below the wale. Remove the sections of the failed wale, repair wale and tension the tie-rod.

Perform pull tests of the existing tie-rods to determine their and the dead men capacity.

Phase 2 (permanent repair)

We recommend increasing the height of the waterside rip-rap berm to an elevation higher than the proposed temporary elevation 0 (to be determined).

We will provide a detailed analysis of this option considering rip-rap elevation immediately adjacent to the sheet pile wall and slope. This will be performed upon receipt of the bathymetric survey.

Based on the proposed permanent rip-rap slope, additional repairs to the existing waler and connections of the corner returns will be considered and designed if appropriate.

Depending on the schedule and the results of our analysis for the permanent repair, implementing the permanent repair immediately could be considered.

## LIST OF APPENDIXES

Appendix A: AMEC Model
Appendix B: RA Consultants LLC replica of AMEC model
Appendix C: RA Consultants LLC independent model

## LIMITATIONS

Our recommendations presented above are based on our interpretation of subsurface conditions based on the data provided and our understanding of the project as described above. If subsurface conditions are found to differ from those described above or if project conditions change we should be requested to modify our recommendations as necessary.

We appreciate this opportunity to be of service.

Very truly yours,

**RA CONSULTANTS LLC**

Walter J. Papp, Jr. PE

# APPENDIX A

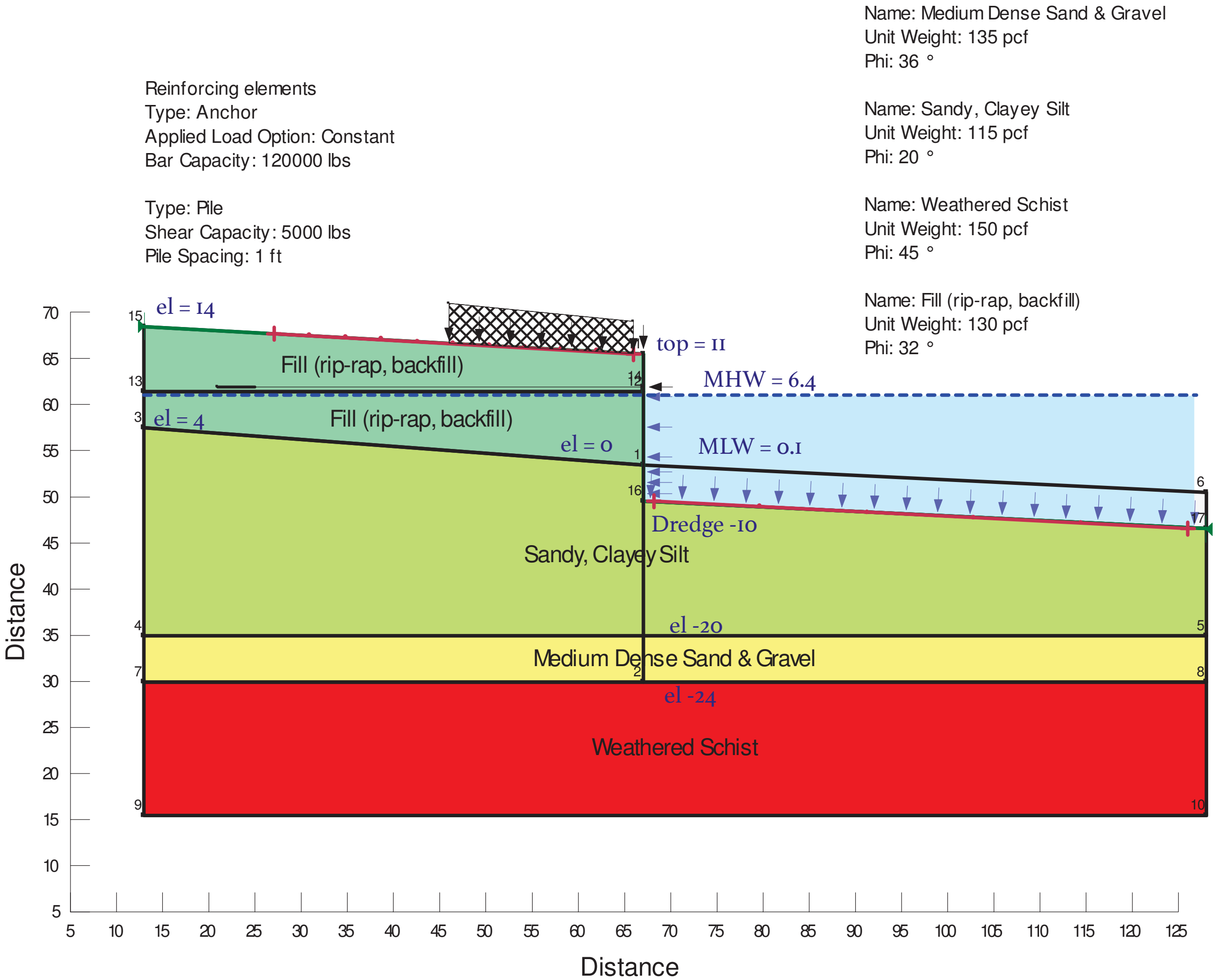



**Figure 5 – Typical Design Profile (Analysis Section A)**

When Analysis Section A was analyzed using SLOPE/W, a FS of 2.225 was calculated against failure (Figure 6). Similarly, Prosheet calculated a required sheet pile penetration of just over 35.5 feet, yielding a FS of 3.335 (Figure 7). The FS calculated in the ProSheet program is a function of the allowable stress available in the sheet pile section selected and maximum stress calculated in the wall section. Also to note is that the calculated required anchor force, 6.33 kips per foot of wall, or approximately 76 kips, is less than the specified 108 kips for this section of wall. This indicates that the anchors are not overstressed.

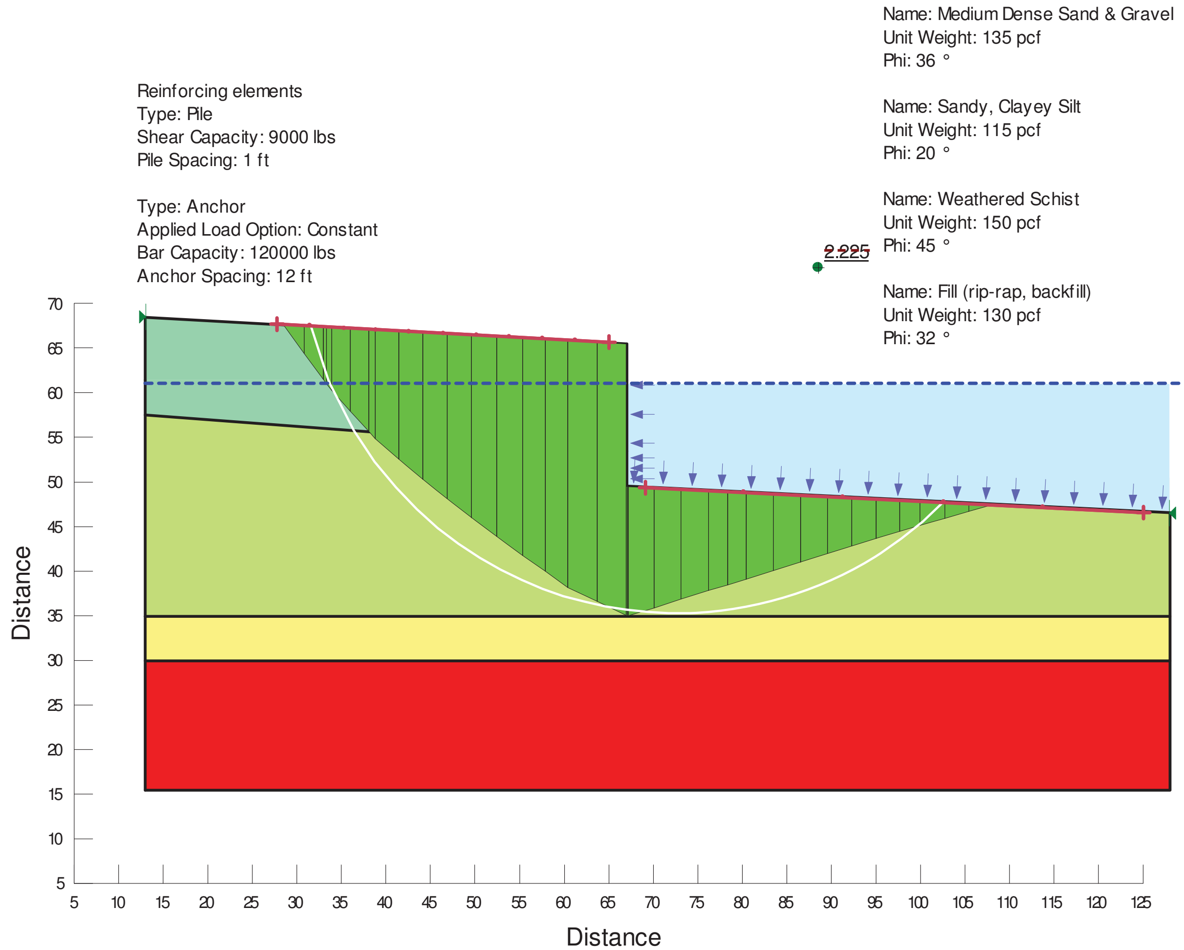



**Figure 6 – Analysis Results for Section A**

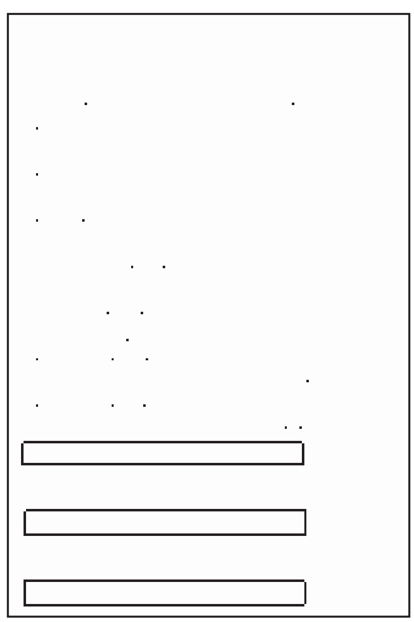
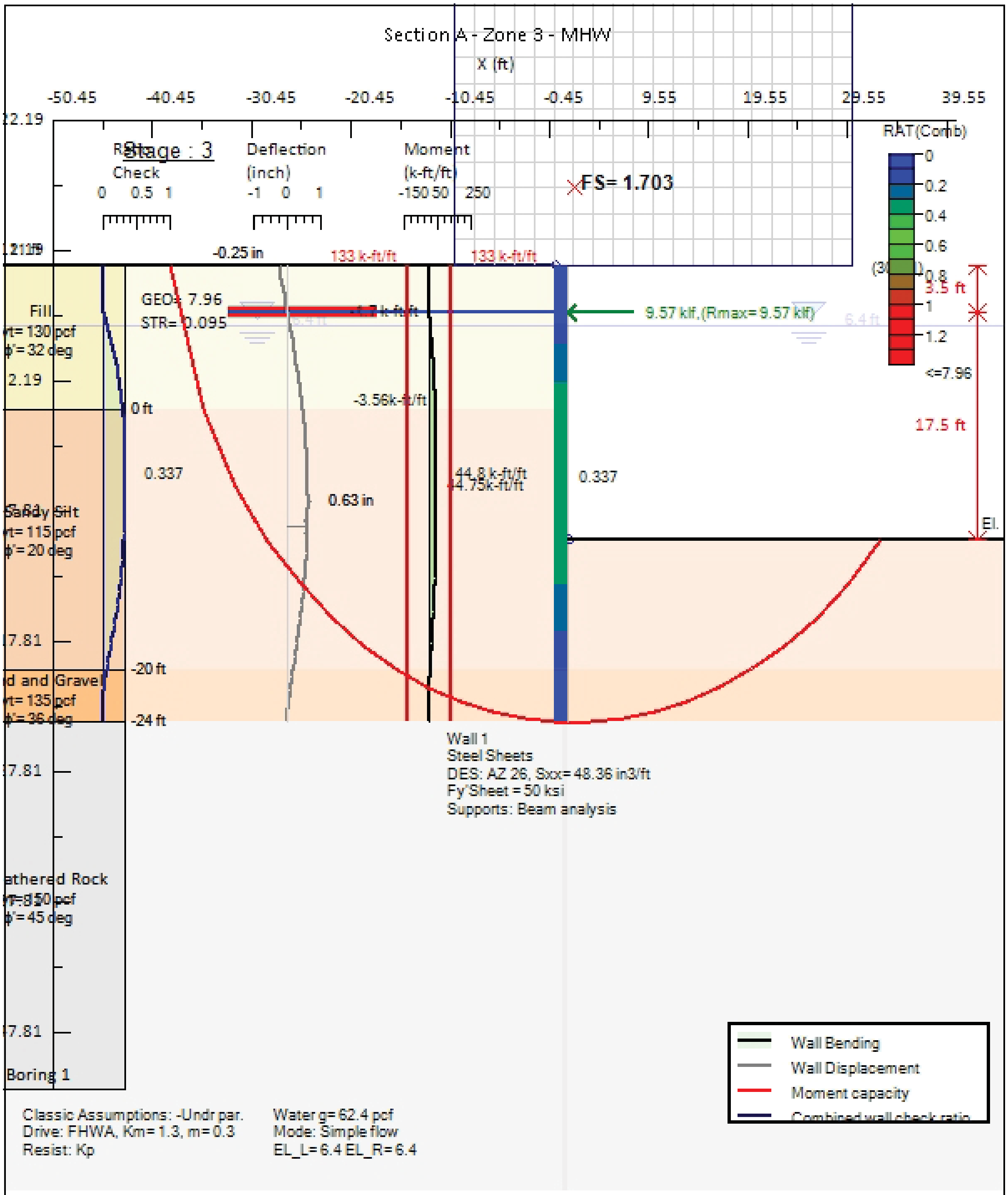


**Figure 7 –ProSheet Output for Section A**

# APPENDIX B

***Project: Metal Bank***
***Results for Design Section 0: Section A - Zone 3 - MHW***

## ANALYSIS AND CHECKING SUMMARY

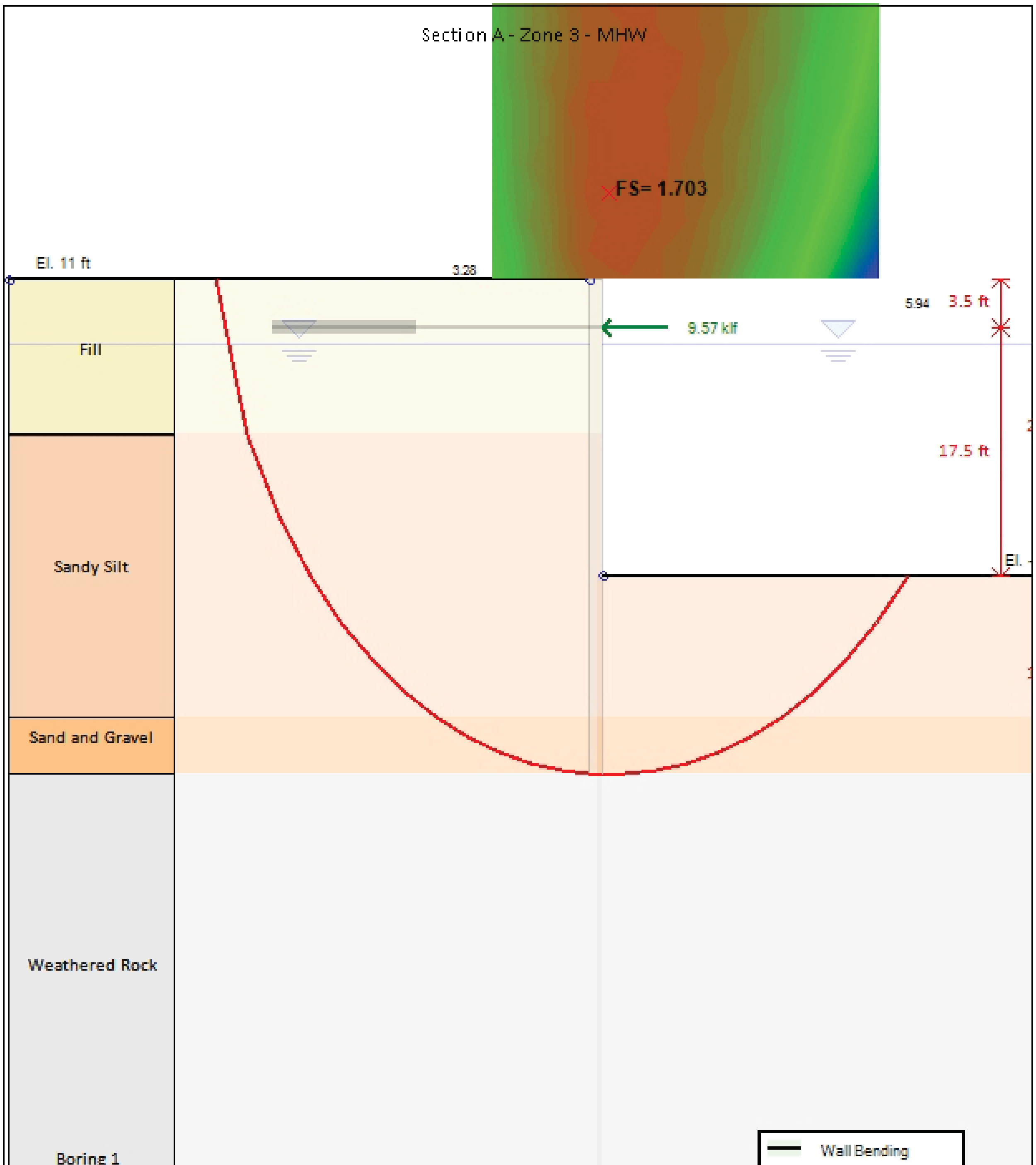



| Company: RA Consultants LLC | Quick summary | Deep Excavation LCC |
|---|---|---|
| Engineer: Engineer | | DeepEX 2014 |
| W:\RA..jects\12C1135 Metal Bank\Engineering\20140803 JR Zone 3.DEEP | | 8/3/2014 |

Summary of Wall Moments and Toe Requirements

## EXCAVATION STAGES AND SLOPE STABILITY

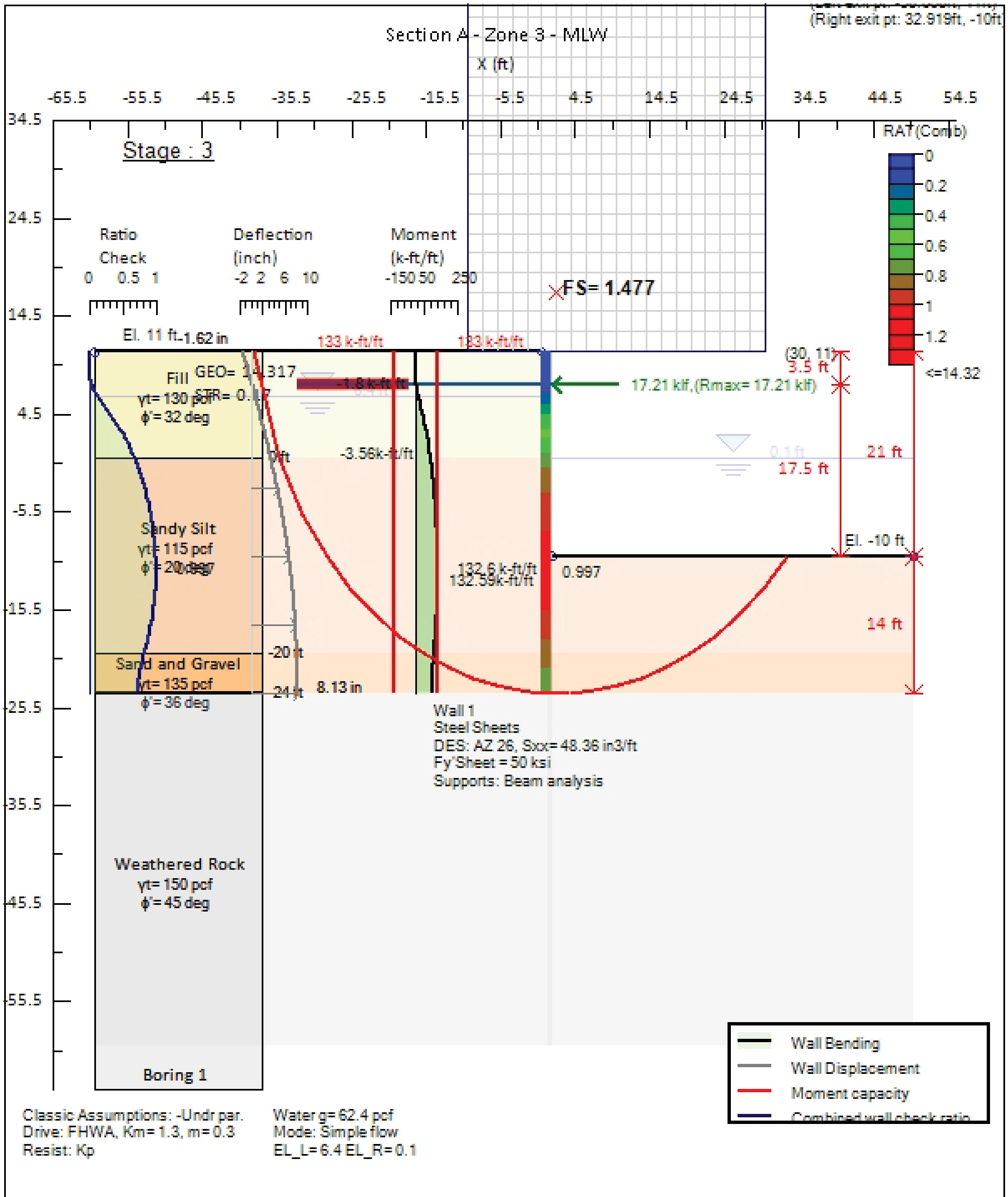
Reports a sequence of figures for each stage with slope stability results.




| Company: RA Consultants LLC<br>Engineer: Engineer | DS: 0, Stage 3 | Deep Excavation LCC<br>DeepEX 2014 |
|---|---|---|
| W:\RA..jects\12C1135 Metal Bank\Engineering\20140803 JR Zone 3.DEEP | | 8/3/2014 |

*Project: Metal Bank*
*Results for Design Section 1: Section A - Zone 3 - MLW*

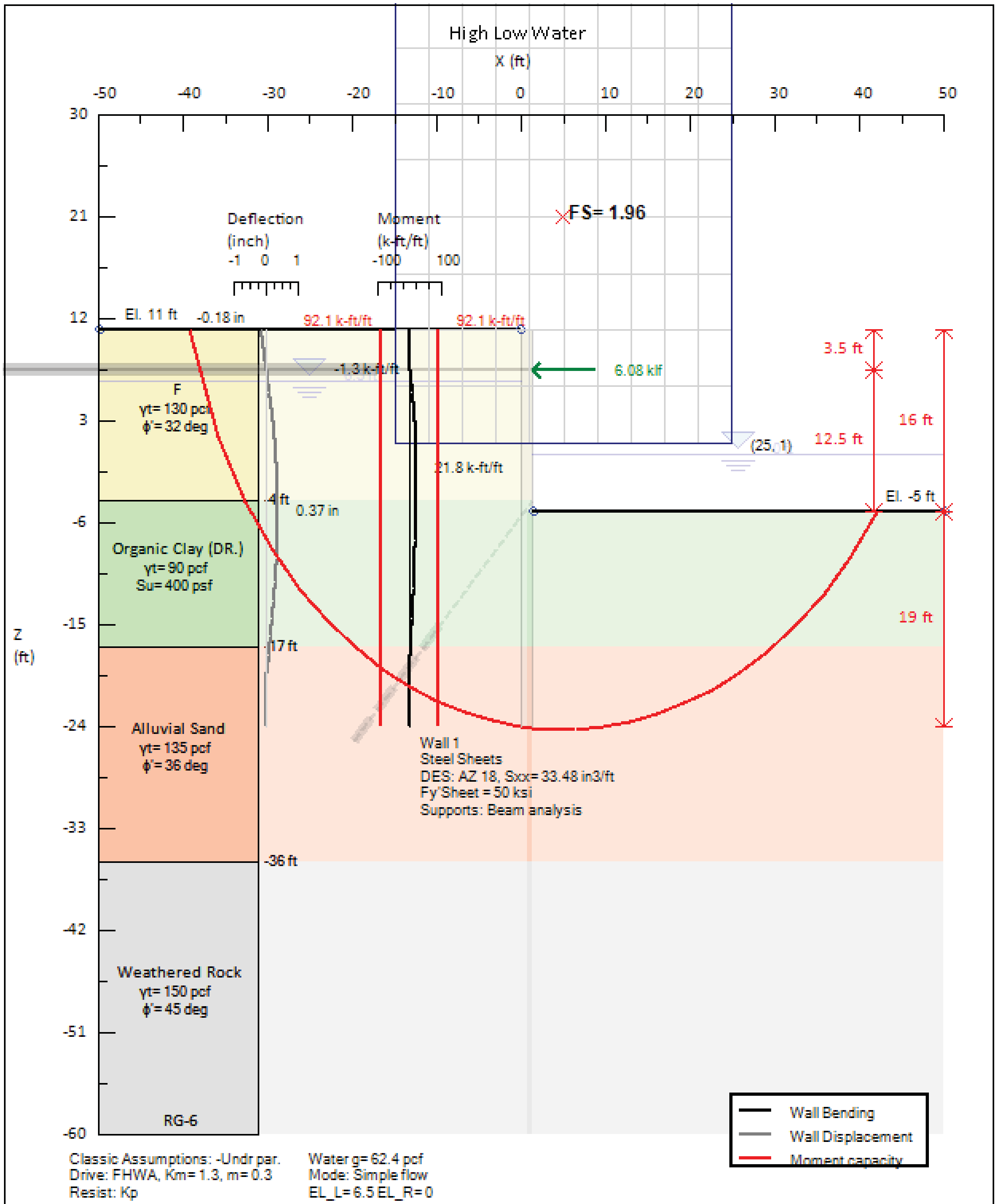
## ANALYSIS AND CHECKING SUMMARY



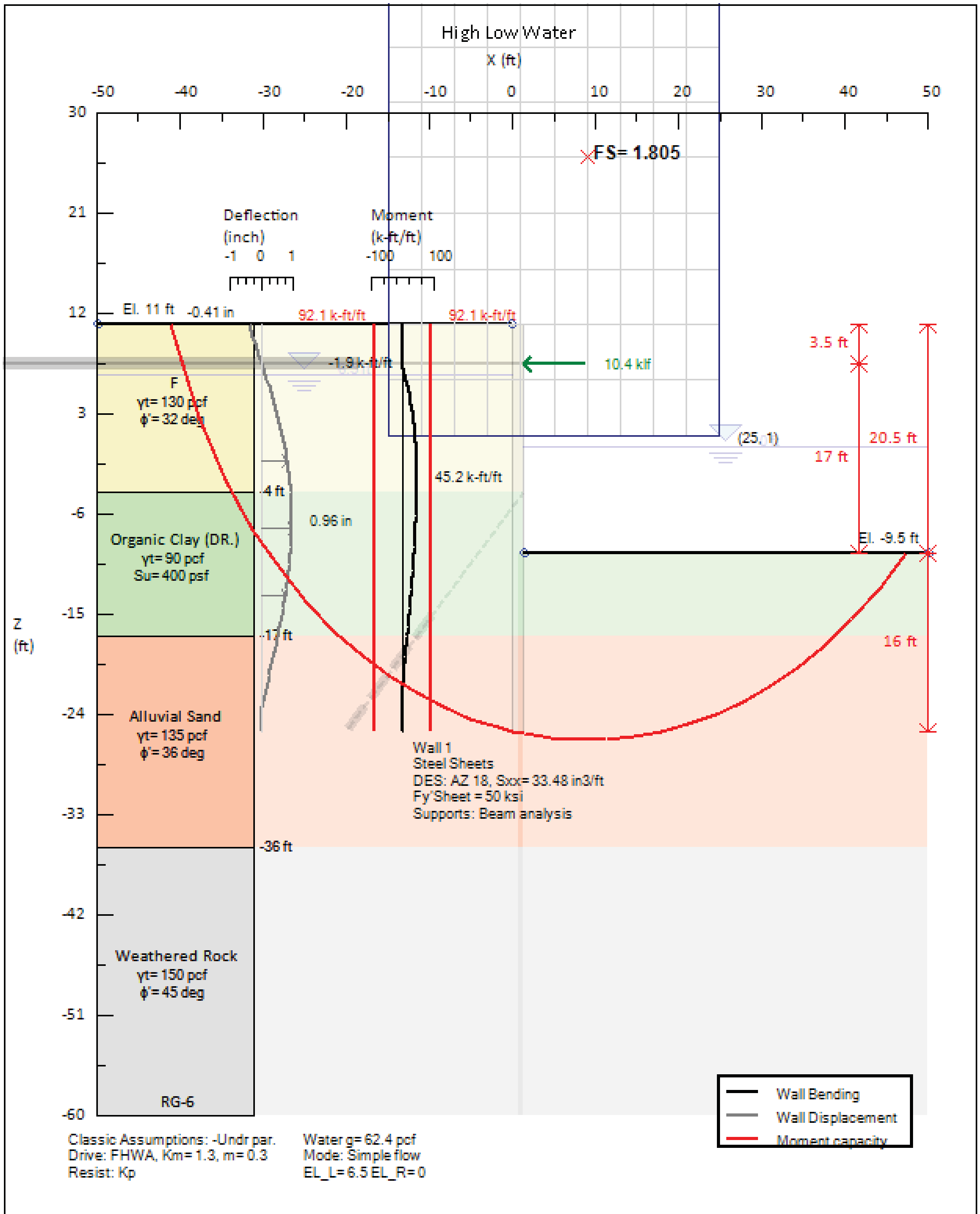

| Company: RA Consultants LLC | Quick summary | Deep Excavation LCC |
|---|---|---|
| Engineer: Engineer | | DeepEX 2014 |
| W:\RA..jects\12C1135 Metal Bank\Engineering\20140803 JR Zone 3.DEEP | | 8/3/2014 |

Summary of Wall Moments and Toe Requirements

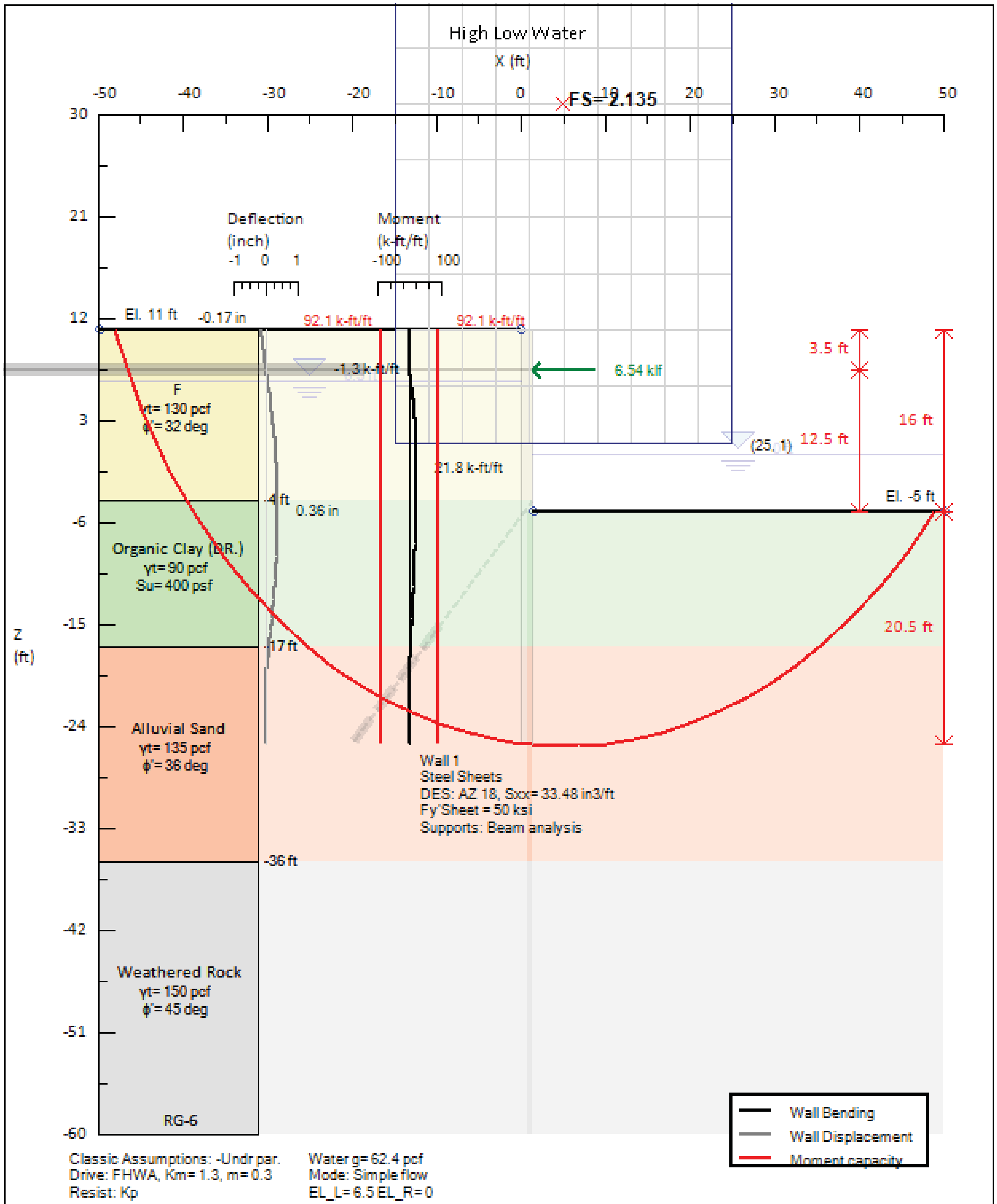
# APPENDIX C



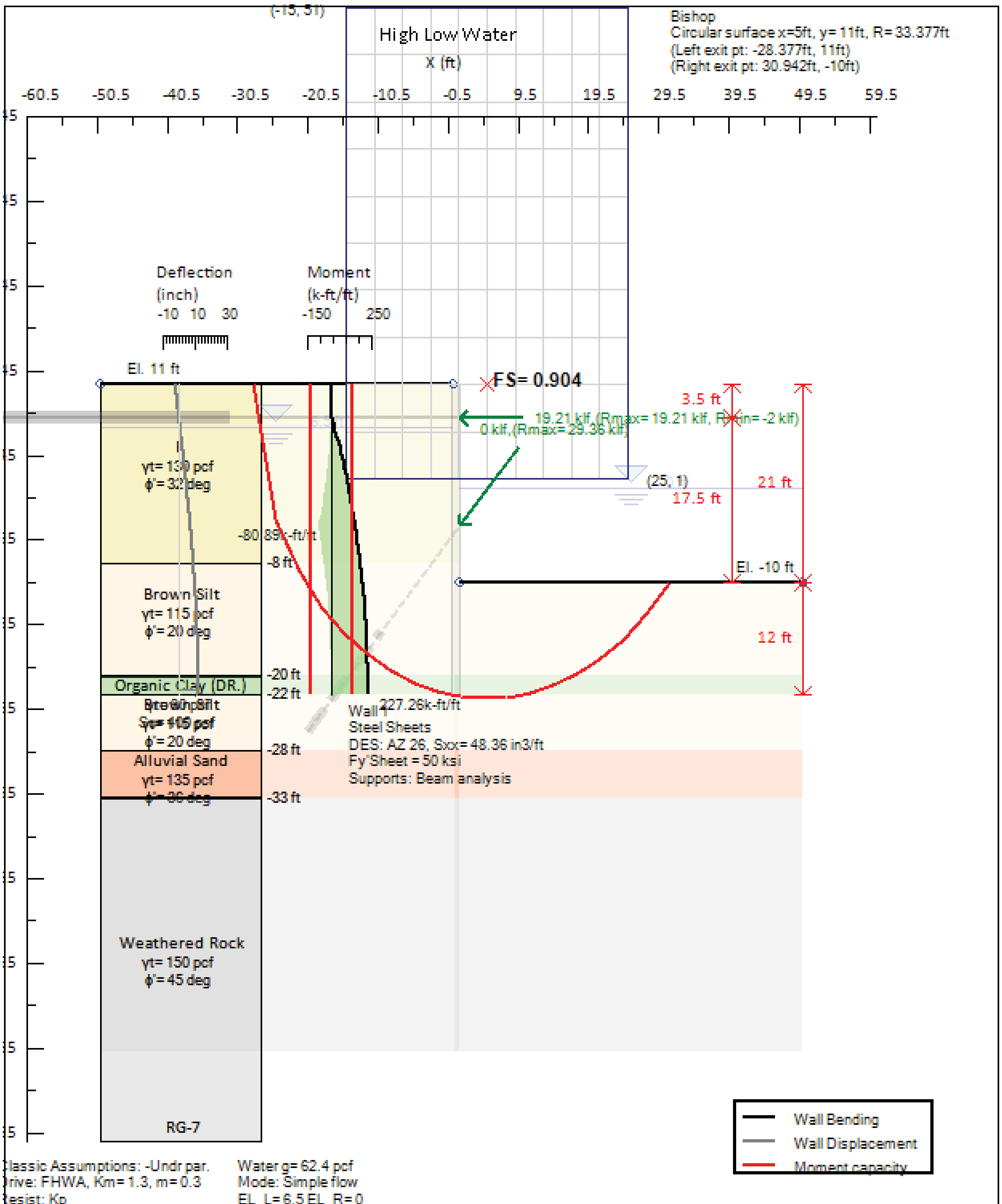

| | | |
|---|---|---|
| Company: RA Consultants LLC<br>Engineer: Engineer | Stage 4 | Deep Excavation LCC<br>DeepEX 2014 |
| C:\Us..ne 1\20140812 JR Zone 1 - Previous Borings Model - AZ18.DEEP | | 8/26/2014 |



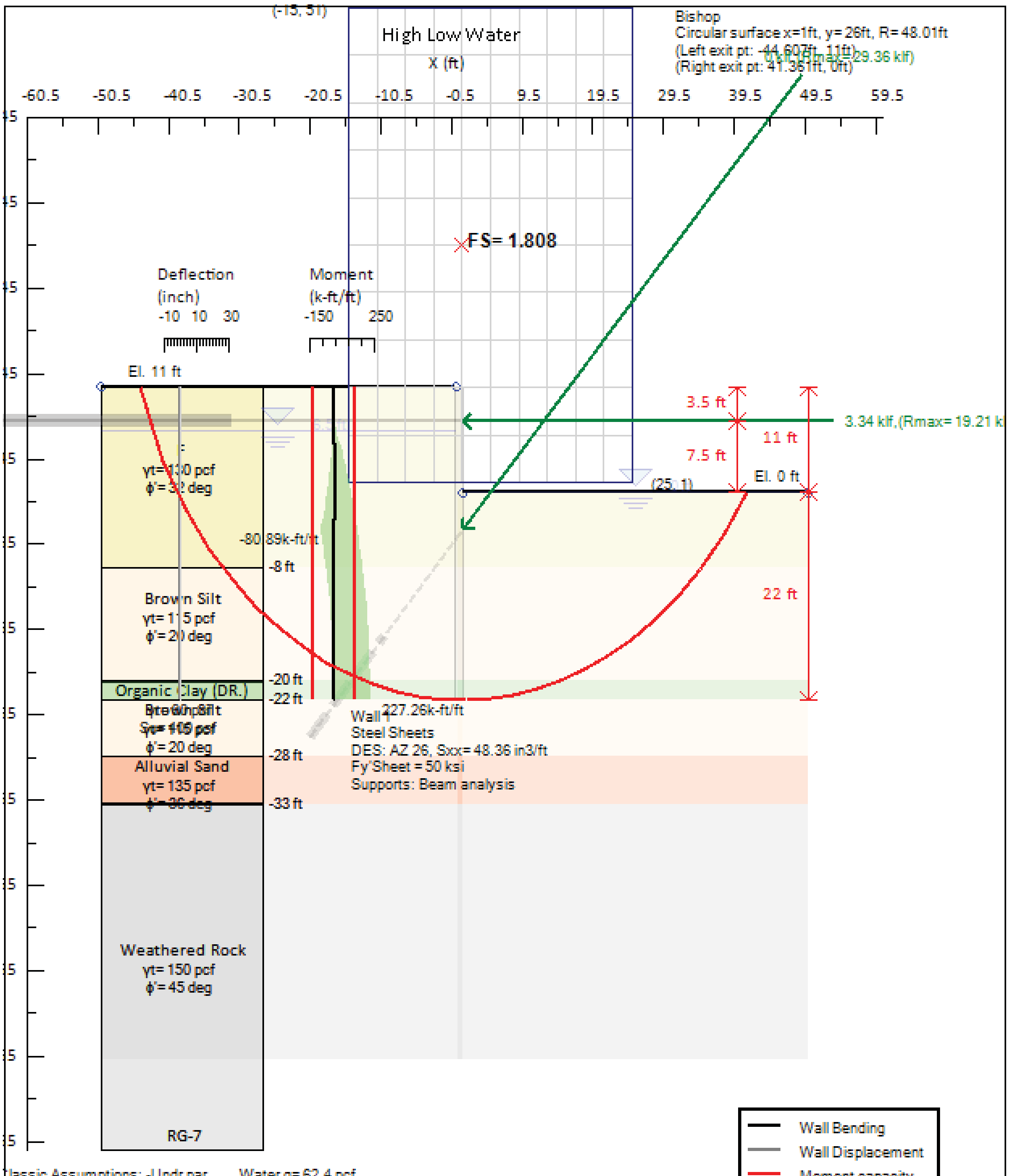

| | | |
|---|---|---|
| Company: RA Consultants LLC<br>Engineer: Engineer | Stage 4 | Deep Excavation LCC<br>DeepEX 2014 |
| C:\Us..ne 2\20140812 JR Zone 2 - Previous Borings Model - AZ18.DEEP | | 8/26/2014 |




| | | |
|---|---|---|
| Company: RA Consultants LLC | Stage 3 | Deep Excavation LCC |
| Engineer: Engineer | | DeepEX 2014 |
| C:\Us..ne 2\20140812 JR Zone 2 - Previous Borings Model - AZ18.DEEP | | 8/26/2014 |




| | | |
|---|---|---|
| Company: RA Consultants LLC<br>Engineer: Engineer | Stage 4 | Deep Excavation LCC<br>DeepEX 2014 |
| C:\Us..ne 3\20140812 JR Zone 3 - Previous Borings Model - AZ26.DEEP | | 8/26/2014 |




Classic Assumptions: -Undr par.
Drive: FHWA, Km= 1.3, m= 0.3
Resist: Kp

Water g= 62.4 pcf
Mode: Simple flow
EL_L= 6.5 EL_R= 0

| | | |
|---|---|---|
| Company: RA Consultants LLC<br>Engineer: Engineer | Stage 3 | Deep Excavation LCC<br>DeepEX 2014 |
| C:\Us..ne 3\20140812 JR Zone 3 - Previous Borings Model - AZ26.DEEP | | 8/26/2014 |

# Appendix 2

## Aqua Survey, Inc. Near-shore Bathymetric Survey conducted on October 10, 2014 (Not included in this draft)

## LEGEND

- CHAINLINK FENCE
- LEGAL RIGHT OF WAY
- PROPERTY LINE
- EDGE OF PAVEMENT
- EDGE OF STONE
- EDGE OF WATER
- JUNCTION BOX
- UTILITY POLE
- BENCH MARK
- MONITORING WELL
- RIP-RAP
- OUTLINE CONCRETE LNAPL SUMPS
- (100.569') PHILADELPHIA DISTRICT STANDARD MEASURE
- 100.569' U.S. STANDARD MEASURE

## REFERENCE PLANS

1. PLANS ENTITLED "UNITED STATES ENVIRONMENTAL PROTECTION AGENCY REGION 3, REVISED REMEDIAL DESIGN, METAL BANK SITE, PHILADELPHIA, PENNSYLVANIA" SHEETS 1 THRU 49, PREPARED BY: AMEC EARTH & ENVIRONMENTAL, INC., PLYMOUTH MEETING, PA, DATED: 11/09/2007 & 4/04/2008.
2. PLAN ENTITLED "HYDROGRAPHIC SURVEY, METAL BANK NPL SITE, PRE-EXCAVATION SURVEY, SITUATED IN CITY OF PHILADELPHIA, PHILADELPHIA COUNTY, PENNSYLVANIA", PREPARED BY: LGA ENGINEERING, INC., LAKEWOOD, NJ, DATED: 9/08/2008.

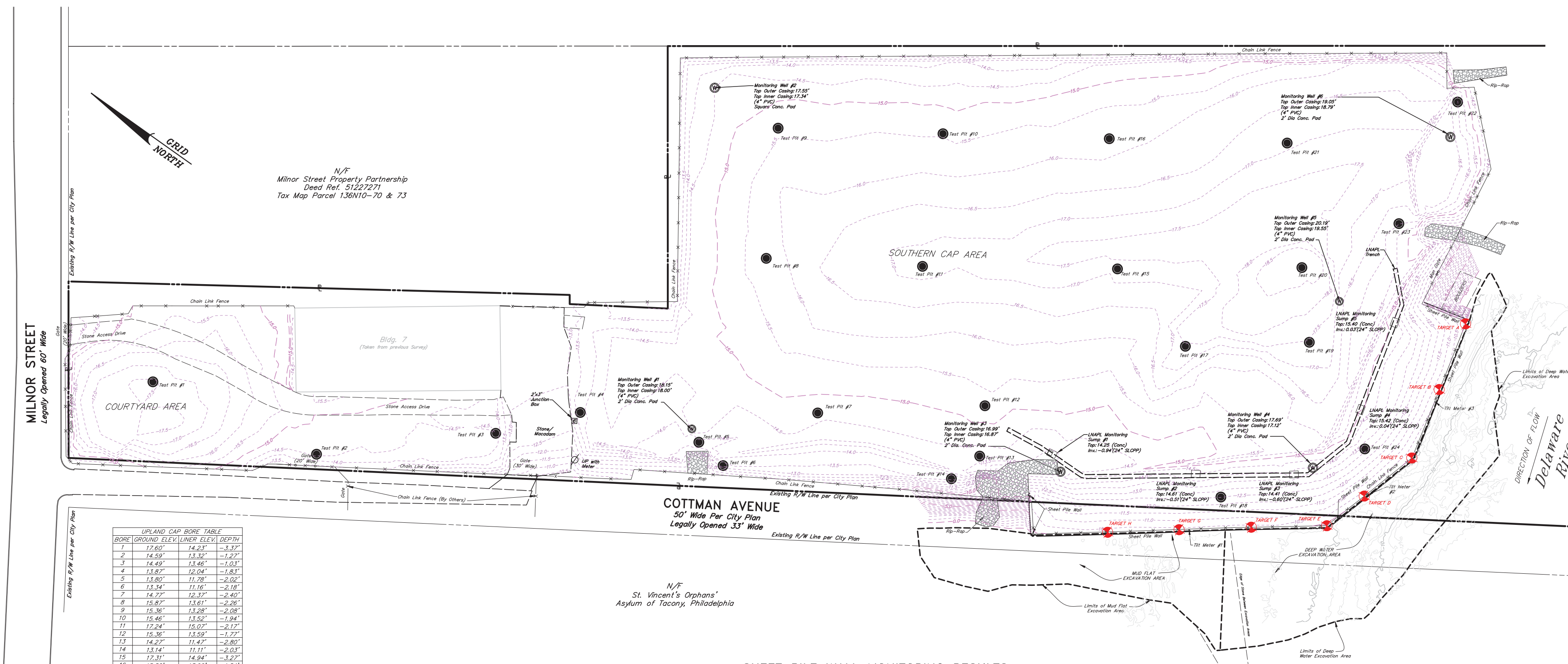
## GENERAL NOTES

PROJECT COORDINATE SYSTEM:
HORIZONTAL: PENNSYLVANIA STATE PLANE COORDINATE SYSTEM (SPCS), PA SOUTH ZONE, NORTH AMERICAN DATUM 83 (NAD 83)

VERTICAL: NORTH AMERICAN VERTICAL DATUM 1988 (NAVD 88)

SITE BENCHMARK: MAG NAIL IN UTILITY POLE (NO IDENTIFICATION NUMBERS-PRIVATE POLE)
ELEVATION: 12.07'
DATUM: NAVD 88

LOCATION OF THE SUB-AQUEOUS CAPS AND BUTTRESS' WERE LOCATED USING HYDROGRAPHIC METHODS AND SHOULD BE CONSIDERED +/- 1'




| UPLAND CAP BORE TABLE | | | |
|---|---|---|---|
| BORE | GROUND ELEV. | LINER ELEV. | DEPTH |
| 1 | 17.60' | 14.23' | -3.37' |
| 2 | 14.59' | 13.32' | -1.27' |
| 3 | 14.49' | 13.46' | -1.03' |
| 4 | 13.87' | 12.04' | -1.83' |
| 5 | 13.80' | 11.78' | -2.02' |
| 6 | 13.34' | 11.16' | -2.18' |
| 7 | 14.77' | 12.37' | -2.40' |
| 8 | 15.87' | 13.61' | -2.26' |
| 9 | 15.36' | 13.28' | -2.08' |
| 10 | 15.46' | 13.52' | -1.94' |
| 11 | 17.24' | 15.07' | -2.17' |
| 12 | 15.36' | 13.59' | -1.77' |
| 13 | 14.27' | 11.47' | -2.80' |
| 14 | 13.14' | 11.11' | -2.03' |
| 15 | 17.31' | 14.94' | -3.27' |
| 16 | 15.80' | 13.96' | -1.84' |
| 17 | 17.43' | 13.80' | -3.63' |
| 18 | 12.52' | 10.36' | -2.16' |
| 19 | 17.44' | 13.24' | -4.20' |
| 20 | 18.66' | 14.81' | -3.85' |
| 21 | 16.89' | 14.82' | -2.07' |
| 22 | 16.01' | 14.09' | -1.92' |
| 23 | 16.02' | 14.11' | -1.91' |
| 24 | 13.19' | 10.69' | -2.50' |

## CONTOUR LEGEND

- 2012 MINOR CONTOUR LINE
- 2012 MAJOR CONTOUR LINE
- 2014 MINOR CONTOUR LINE
- 2014 MAJOR CONTOUR LINE

## SHEET PILE WALL MONITORING RESULTS

| | 9/4/2014 OBSERVATION SESSION | | | 10/8/2014 OBSERVATION SESSION | | | OBSERVED CHANGE | | |
|---|---|---|---|---|---|---|---|---|---|
| TARGET | NORTH | EAST | ELEV | NORTH | EAST | ELEV | Δ NORTH | Δ EAST | Δ ELEV |
| A | 262142.9 | 2731084 | 15.678 | 262142.9 | 2731084 | 15.695 | 0 | 0.001 | -0.017 |
| B | 262125.9 | 2731013 | 15.65 | 262125.9 | 2731013 | 15.661 | 0.006 | -0.002 | -0.011 |
| C | 262108.3 | 2730940 | 15.651 | 262108.3 | 2730940 | 15.658 | -0.002 | 0.002 | -0.007 |
| D | 262125.3 | 2730881 | 15.632 | 262125.2 | 2730881 | 15.64 | 0.003 | -0.001 | -0.008 |
| E | 262138.8 | 2730834 | 15.589 | 262138.8 | 2730834 | 15.596 | 0.006 | 0.002 | -0.007 |
| F | 262200.7 | 2730788 | 15.612 | 262200.7 | 2730788 | 15.624 | 0.005 | 0.002 | -0.012 |
| G | 262259.1 | 2730744 | 15.596 | 262259.1 | 2730744 | 15.6 | -0.009 | 0.01 | -0.004 |
| H | 262316.9 | 2730699 | 15.611 | 262316.9 | 2730699 | 15.614 | -0.011 | 0.004 | -0.003 |

## CERTIFICATION STATEMENT

BY THIS SUBMITTAL, I HEREBY REPRESENT THAT I HAVE DETERMINED AND VERIFIED THE CONTOURS OF THE SOUTHERN CAP AREA AND THE COURTYARD AREA SHOWN HEREON AS OF JUNE 2012.

RONALD L. HORST, PLS NO. SU042033-E, FOR RETTEW ASSOCIATES, INC.

| NO. | DATE | REVISION |
|---|---|---|
| 3 | 10/16/14 | ADDED SHEET PILE MONITORING TABLE |
| 2 | 10/16/14 | ADDED BATHYMETRIC CONTOURS FROM HYDROGRAPHIC SURVEY |
| 1 | 10/16/14 | ADDED MONITORING TARGETS A – H |

FOR RETTEW ASSOCIATES BY:

MANAGER: RONALD L. HORST
DESIGN BY: | CHKD BY: RLH
SURV. CHIEF: RAR | FIELDBOOK NO.
DRAWN BY: EDY | CHKD BY:
XREFS: Metal Bank 1ft Contours filledNAVD88
DRAWING REFERENCE: H:\Projects\09373\093732000\CAD\093732000-Xbase.dwg

CLIENT
ENVIRON
20 Custom House Street,
8th Floor
Boston, MA 02110
Phone: 617-946-6100

SCALE 1"=50'
0 25' 50' 100' 150'


RETTEW
RETTEW Associates, Inc.
223 Windgate Drive, Chester Springs, PA 19425
Phone (610) 458-7000 • Fax (610) 458-3273
Email: rettew@rettew.com
Website: www.rettew.com
Engineers • Planners • Surveyors • Landscape Architects
Environmental Consultants


AS-BUILT SURVEY (10/2014)
For
# METAL BANK NPL SITE
PHILADELPHIA PENNSYLVANIA

DATE: 10-17-2014
SHEET NO. 1 OF 5
DWG. NO. 093732000